CHALLENGES OF SAFAR-OPERATIONAL AIR QUALITY FORECASTING SYSTEM FOR INDIAN METROS

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(Presenter: Gufran Beig, Project Director, SAFAR)

Indian Institute Of Tropical Meteorology, Pune

***India Meteorology Department, New Delhi**

METROPOLITAN ADVISORIES FOR CITIES FOR SPORTS & TOURISM IN INDIA

सत्यमेव जयते
पृथ्वी विज्ञान मंत्रालय

System of Air Quality and Weather Forecasting and Research (SAFAR-India)

ISO 9001:2008 Accredited by Standard Certification Council-India
GURME, World Meteorological Organization Piloted

Metropolitan Air Quality & Weather Services

IITM and IMD

ESSO, Ministry of Earth Sciences, Govt. of India

VISION

SAFAR -OBJECTIVES

SYSTEM DEVELOPMENT

SCIENTIFIC RESEARCH

- Weather Information Services
- Air Quality Information & Advisory
- Impacts: Health & Agriculture
- Innovative Science Issues

PRODUCTS -Citizens

PAPERS -Scientists

SAFAR Mission

"System of Air Quality, Weather Forecasting & Research"

Operational Air Quality Forecasting System for India Metros

Novel program of Govt. of India

MISSION GOAL

Development of early warning system for Air Quality, Weather & UV related information, its up to 3 day advance forecast and associated advisories for the benefit of society.

CITIES DONE 2010-2015

DELHI (2010), PUNE (2013), MUMBAI (2015)

CITIES TO BE DONE 2015-2017

AHMEDABAD, CHENNAI, KOLKATA

Operational

Ongoing

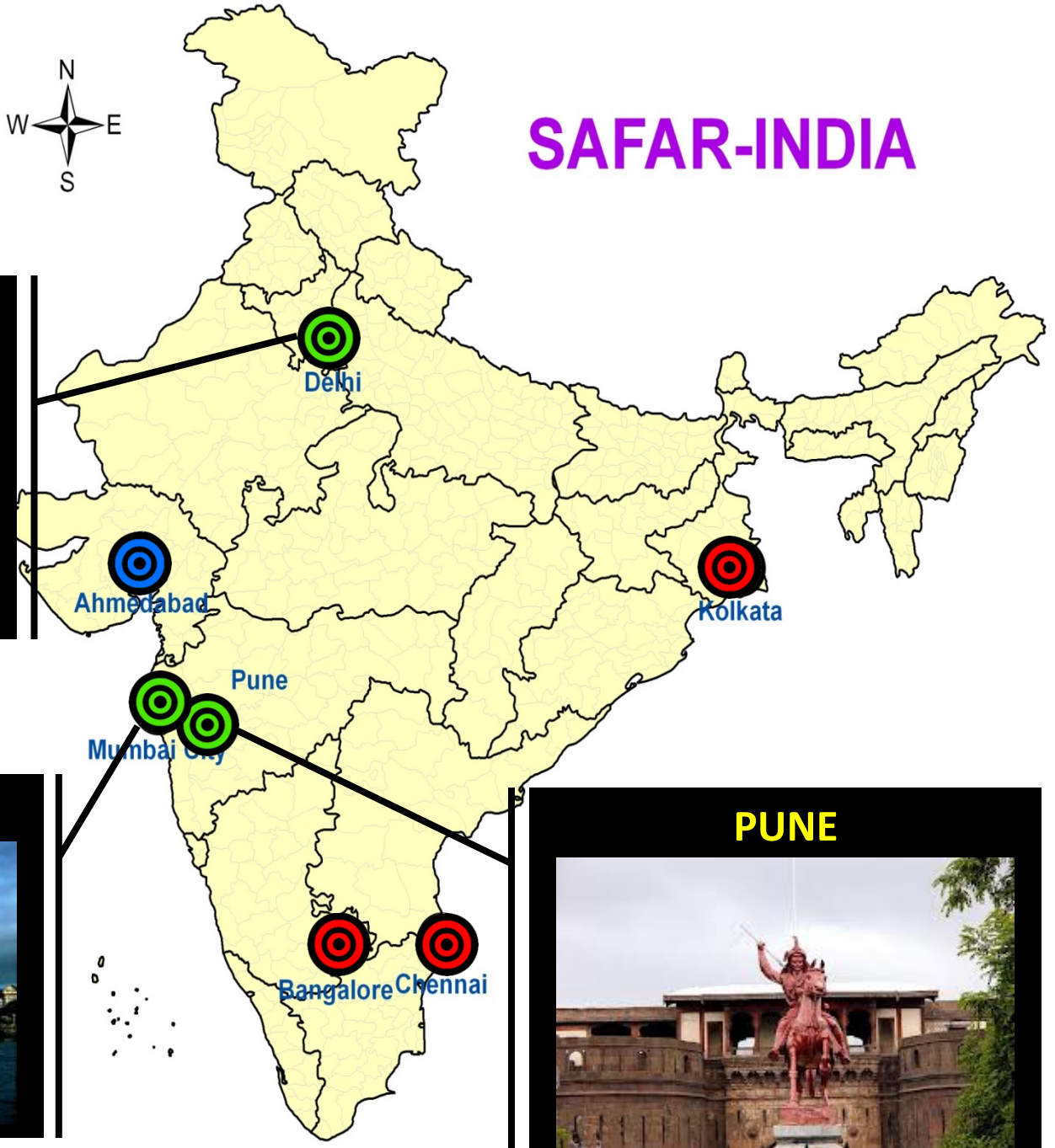
Upcoming

SAFAR-INDIA

DELHI

MUMBAI

PUNE

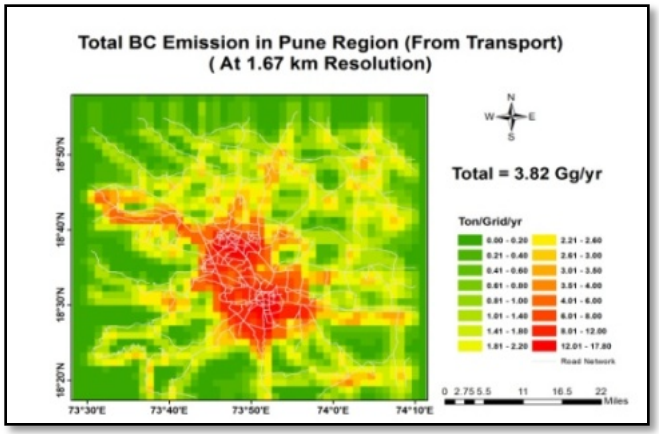


SAFAR- SYSTEM COMPONENTS

1 OBSERVATIONAL NETWORK

Air Quality & Weather Monitoring

2 EMISSION INVENTORIES

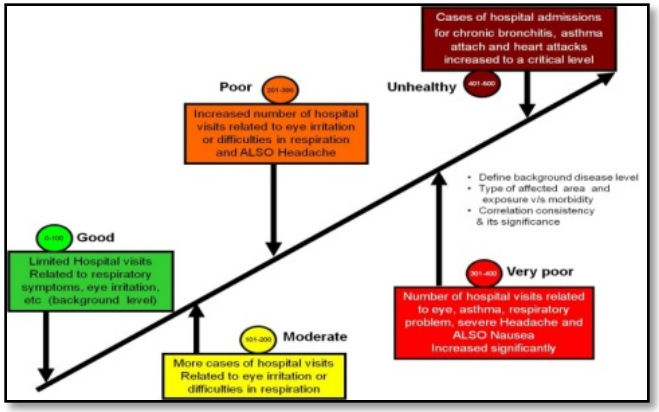


Accounting sources of pollution

3 FORECASTING MODEL

Air Quality & Weather Forecasting

4 COMMUNICATION MEDIA



Translate Data in to Information

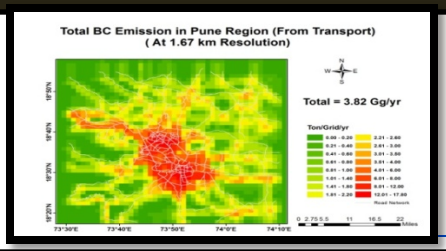
SAFAR-India: FOUR CORE COMPONENTS

OBSERVATIONAL NETWORK

Monitor Air Quality & Weather Parameters at strategically selected locations

PM10, PM2.5, PM1, O3, CO, NOx, CH4, VOCs, SO_2, BC, Hg, Rainfall, Temperature, Humidity, Wind speed, Wind direction, UV Radiation

EMISSION INVENTORIES



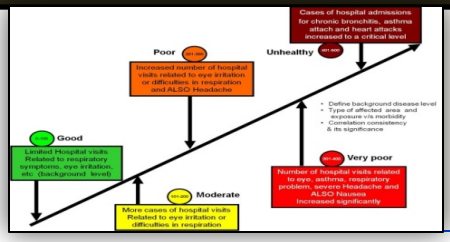
Accounting sources of pollution

Identify air pollution hot spots over city, crucial input for forecasting model

FORECASTING MODEL

Develop capacity to predict air quality 1 to 3 days in advance

OUTREACH

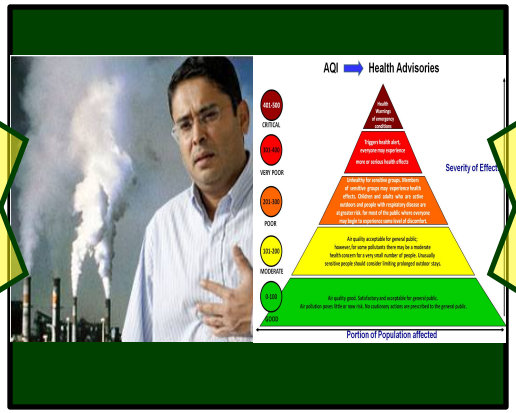


Convert science in to Information

Developed concept of Air Quality Index (AQI) and UV Index (UVI)

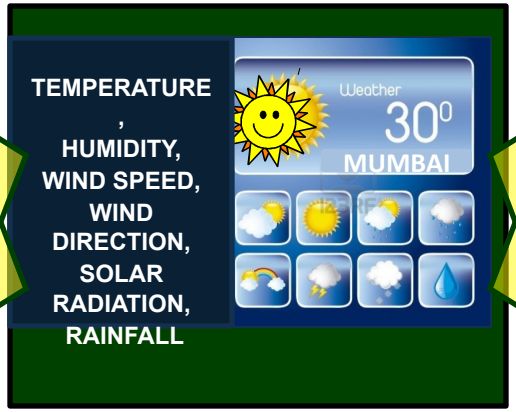
SAFAR- INFORMATION PRODUCTS

AIR QUALITY - RELATED HEALTH ADVISORIES

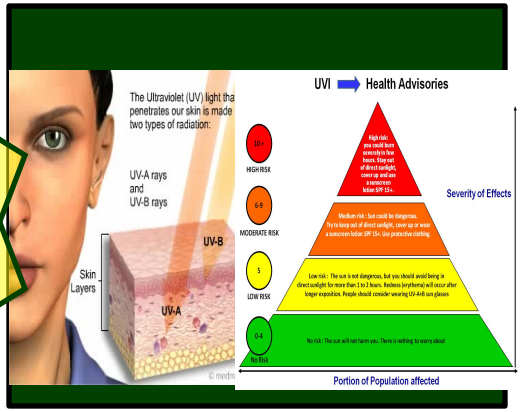


HIGH TIDES/ LOW TIDES

WEATHER CONDITIONS



SUN'S HARMFUL RADIATION (UVI) & SKIN ADVISORIES



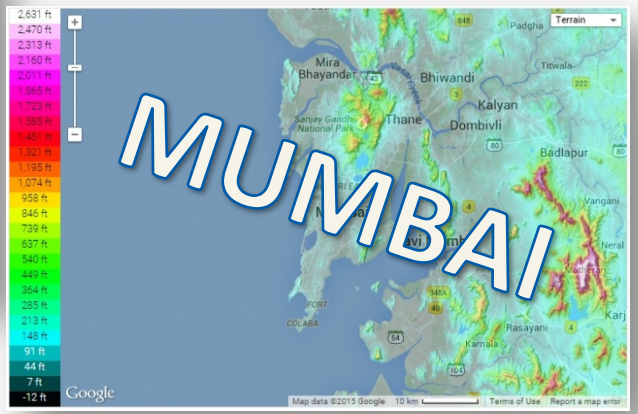
LOCATION SPECIFIC EXTEREME POLLUTION & WEATHER WARNING

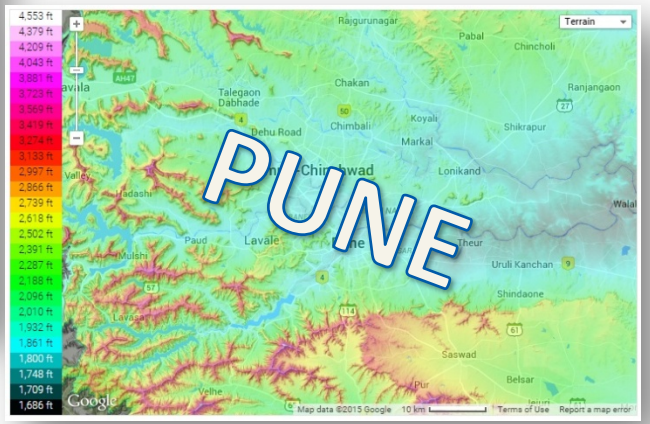
EDUCATIONAL SLOGANS

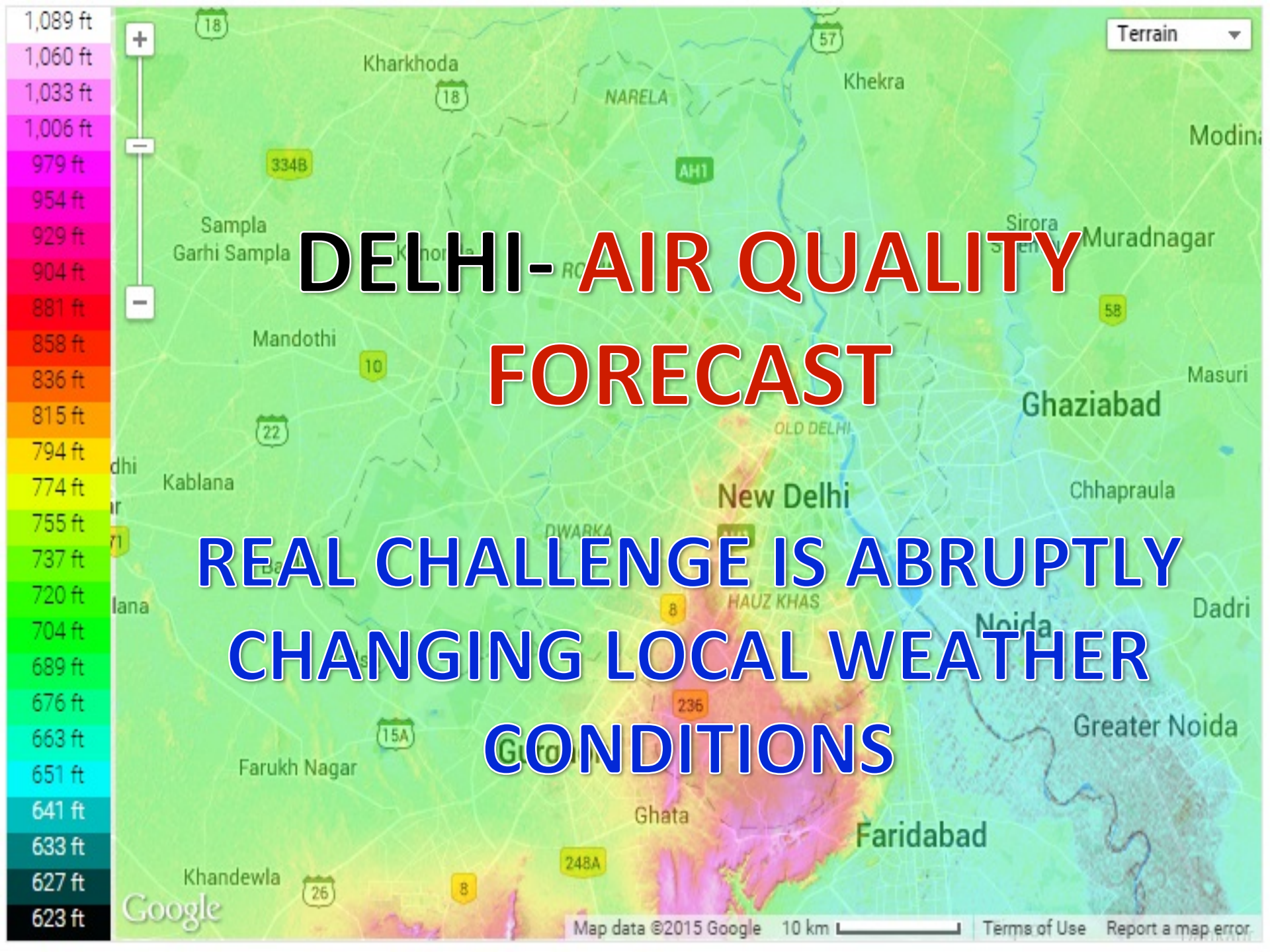
SAFAR SYSTEM DEVELOPMET FOR METROPOLITAN REGIONS

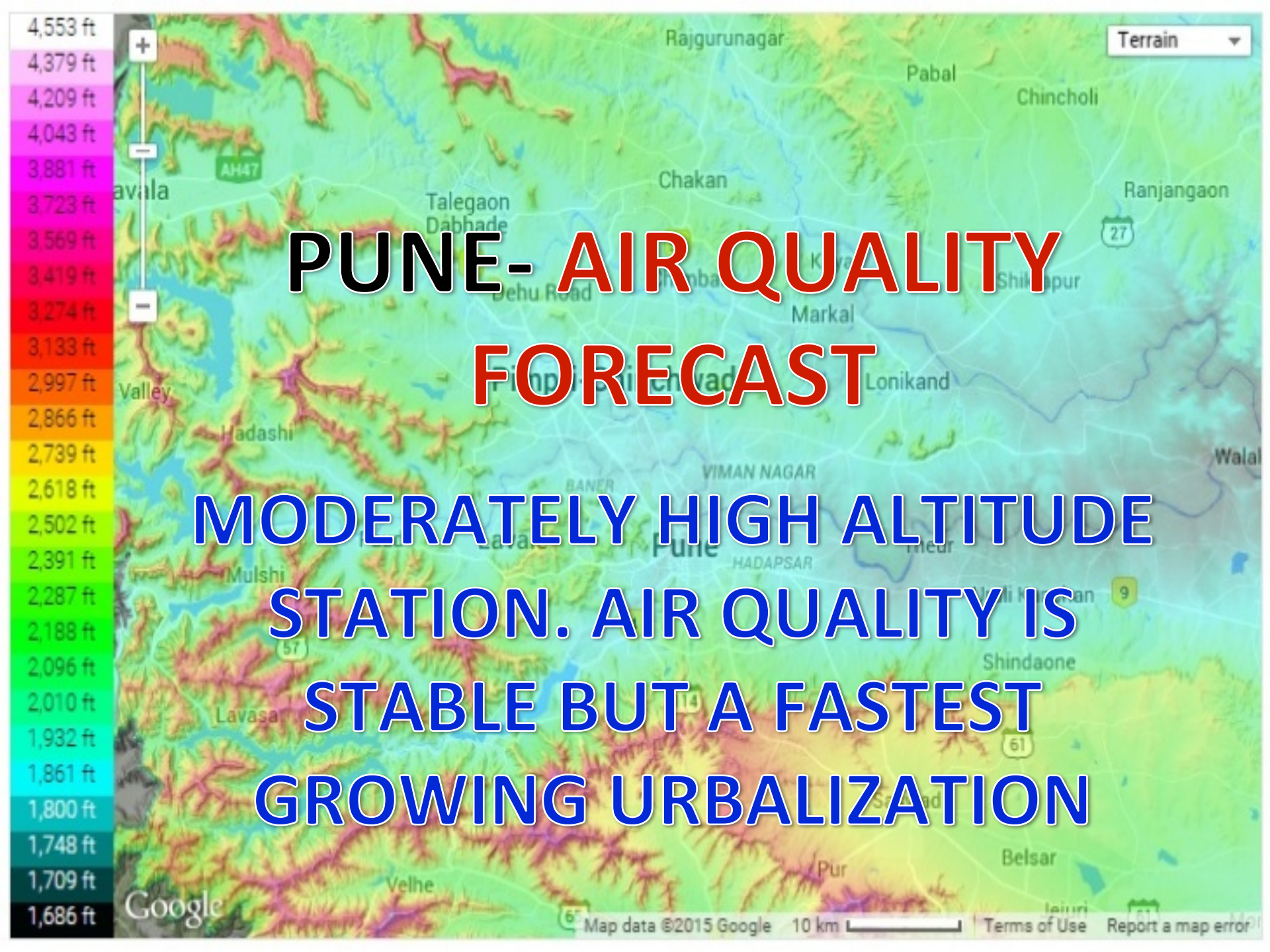
1. Practical
2. Technical
3. Scientific

- DIFFERENT METEOROLOGICAL CONDITIONS
- DIFFERENT TOPOGRAPHY
- DIFFERENT SOCIOECONOIC STATUS
- VARIOUS MICROENVIRONMENTS
- DIFFERENT EMISSION SOURCES



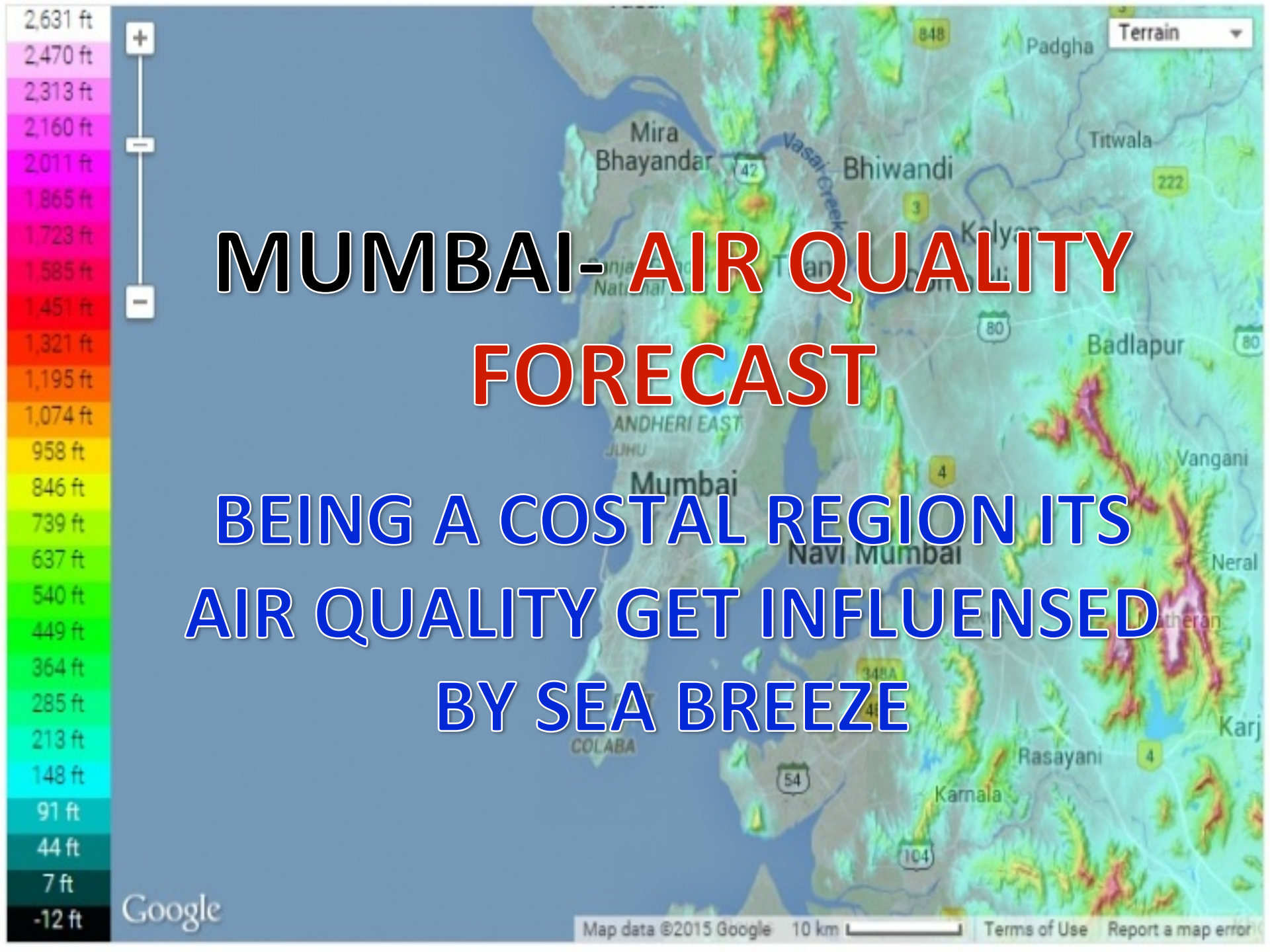



1,089 ft
1,060 ft
1,033 ft
1,006 ft
979 ft
954 ft
929 ft
904 ft
881 ft
858 ft
836 ft
815 ft
794 ft
774 ft
755 ft
737 ft
720 ft
704 ft
689 ft
676 ft
663 ft
651 ft
641 ft
633 ft
627 ft
623 ft
Terrain
Kharkhoda
NARELA
Khekra
Modina
Sampla
Garhi Sampla
Sirora
Muradnagar
Mandothi
Masuri
Ghaziabad
OLD DELHI
Kablana
New Delhi
Chhapraula
DWARKA
HAUZ KHAS
Noida
Dadri
Greater Noida
Farukh Nagar
Ghata
Faridabad
Khandewla
Google
Map data ©2015 Google
10 km
Terms of Use
Report a map error
DELHI- AIR QUALITY FORECAST
REAL CHALLENGE IS ABRUPTLY CHANGING LOCAL WEATHER CONDITIONS



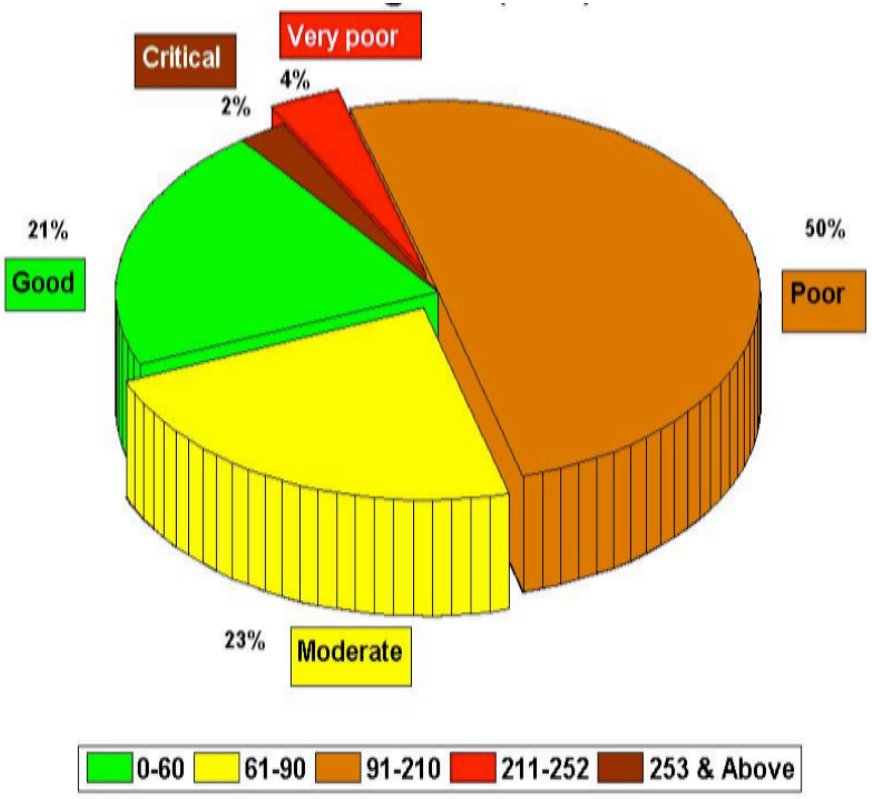
PUNE- AIR QUALITY FORECAST

MODERATELY HIGH ALTITUDE STATION. AIR QUALITY IS STABLE BUT A FASTEST GROWING URBALIZATION

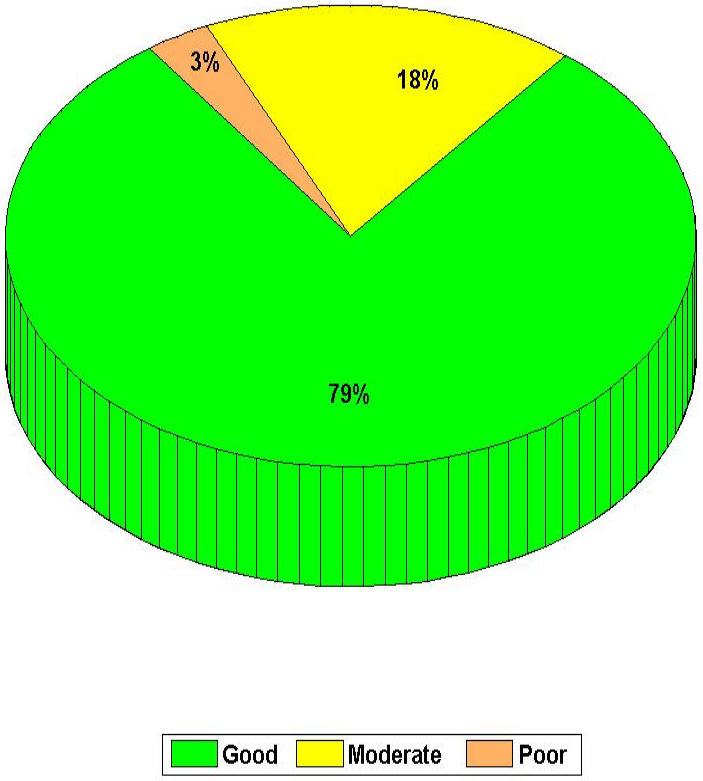

2,631 ft
2,470 ft
2,313 ft
2,160 ft
2,011 ft
1,865 ft
1,723 ft
1,585 ft
1,451 ft
1,321 ft
1,195 ft
1,074 ft
958 ft
846 ft
739 ft
637 ft
540 ft
449 ft
364 ft
285 ft
213 ft
148 ft
91 ft
44 ft
7 ft
-12 ft
Terrain
Padgha
Mira Bhayandar
Vasai Creek
Bhiwandi
Titwala
Kalyan
Badlapur
ANDHERI EAST
JUHU
Mumbai
Navi Mumbai
Vangani
Neral
Karj
COLABA
Rasayani
Kamala
MUMBAI- AIR QUALITY FORECAST
BEING A COSTAL REGION ITS AIR QUALITY GET INFLUENSED BY SEA BREEZE
Google
Map data ©2015 Google
10 km
Terms of Use
Report a map error

AI R QUALITY (PM2.5): DELHI v/s PUNE

DELHI



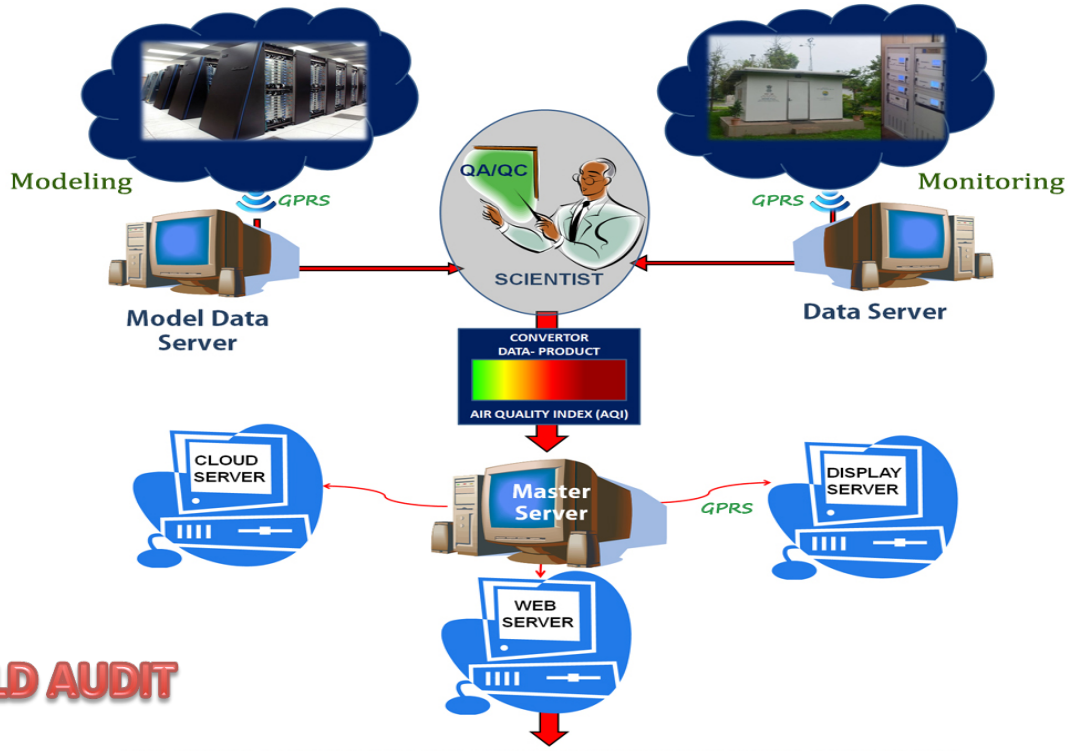
PUNE



A CRITICAL AUDIT PROTOCOL-
QUALITY CONTROL AND QUALITY ASSURANCE

It is an essential step performed by the scientist of IITM before releasing the air quality data to public

- **NON-SCIENTIFIC AUDIT: FULL SYSTEM BY EXTERNAL AGENCY -ISO**
- **TECHNICAL AUDIT: INSTRUMENTAL HEALTH AND CUMMUNICATION**
- **SCIENTIFIC QA & QC: OPERATIONAL SAFAR TEAM OF SCIENTISTS**



- **ECONOMIC YIELD AUDIT**

SITE SELECTION: IDENTIFY MICRO ENVIRONMENT

INDUSTRIAL AREA

AIRPORT SITE

URBAN COMPLEX

Strategic Observational Network

Air Quality Monitoring

Weather Monitoring

RESIDENTIAL AREA

SLUM AREA

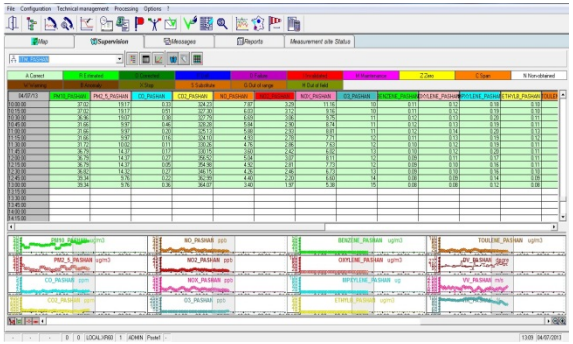
ROAD SIDE

BACKGROUND

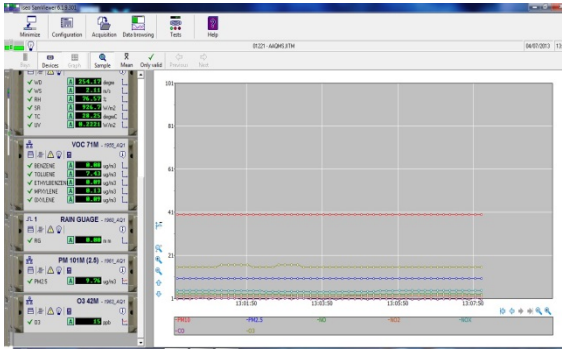
TRAFFIC JUNCTION

AGRICULTURAL AREA

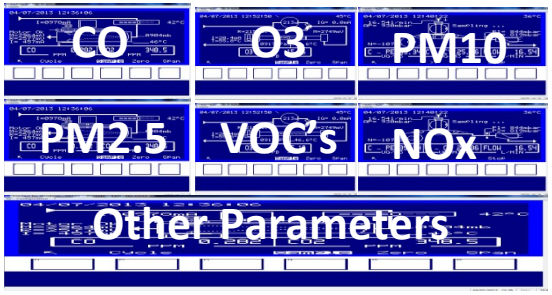
OBSERVATIONS: Date Quality Control & Quality Check



Applying Quality Code



Per second data



Analyzers

Quality codes

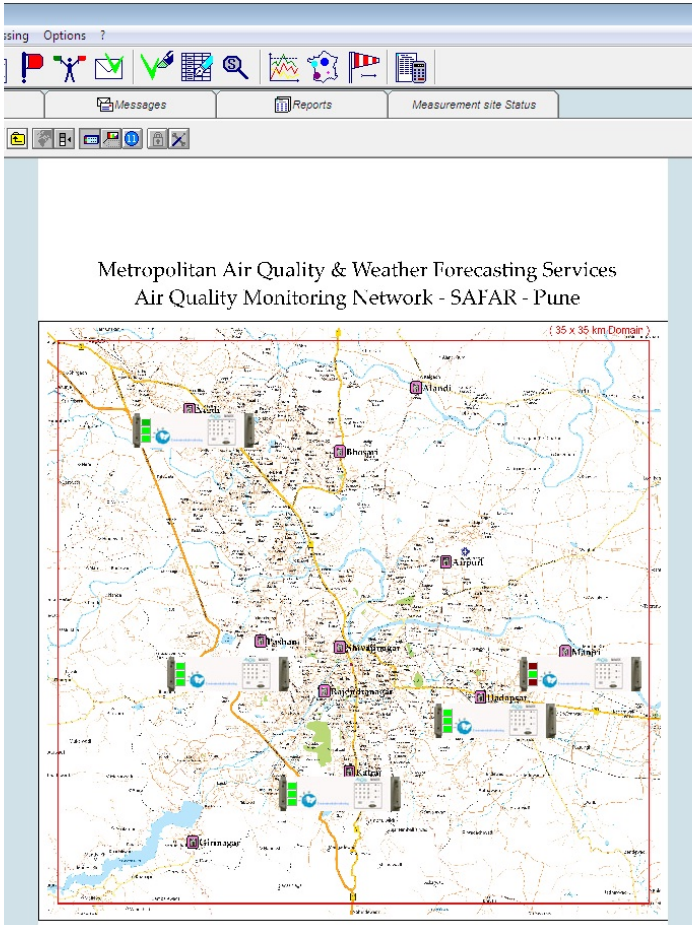
A data is build of a value and a **quality code**.
The value comes from the physical measurement.
The quality code is set to the measurement by the acquisition system according to information relating to the state of the sensor or measurement, but it may be modified by the operator according to information provided by the system.
The quality codes managed by the application are described in the following table:

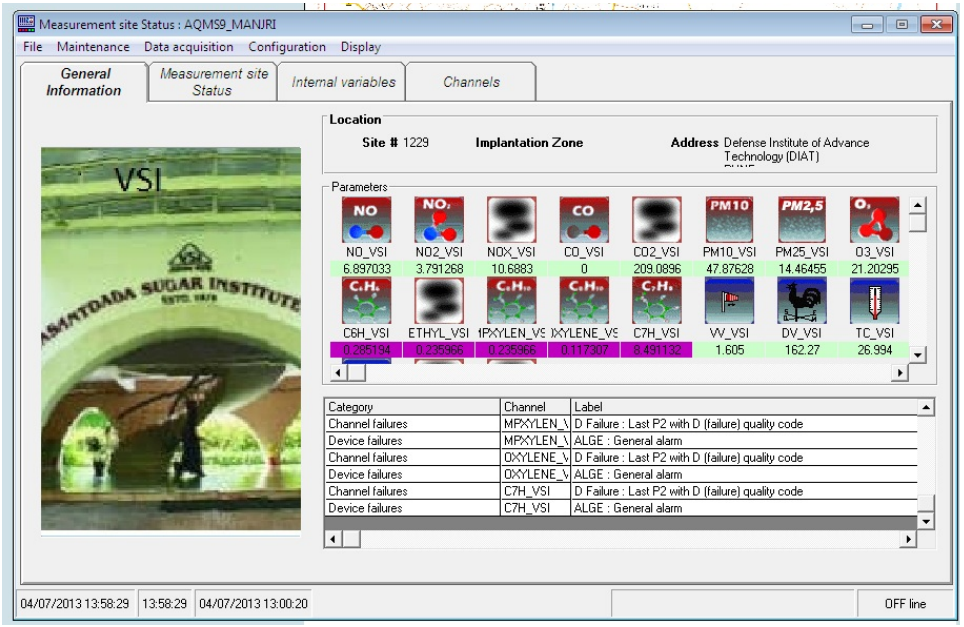
Code	Name	Origin	Explanation
A	Usable	Acquisition System	Data considered to be usable without any reserve.
O	Corrected	Operator	Modification of the value by action of the operator.
R	Reconstituted	Operator	Entry or recalculation of the value by action of the operator.
P	In Drift	Acquisition System	On observation of a drift at the end of an operation of calibration.
W	Warning	Acquisition System	On detection of conditions questioning the quality of data. This code is present only on not validated data. After validation, it is replaced by the code A (Usable).
B	Anomaly	Acquisition System	When a part of scans, lower than the rate of representativeness, is absent. This code is present only on not validated data. After validation, it is replaced by the code A (Usable).
I	Invalid	Operator	Data considered as invalid, following checking.
D	In Failure	Acquisition System	On detection of a faulty material operation.
M	In Maintenance	Acquisition System / Operator	By indication of an on site operator.
Z	In Zero	Acquisition System	For the data gathered during a calibration zero phase.
C	In Span	Acquisition System	For the data gathered during a calibration span phase.
N	Not Acquired	Central System	For data not yet acquired.
X*	Stop	Acquisition System	For data acquired during a period where the process is stopped. When 33% of the avergae is in Stop, the mean will be in Stop. This code is only available by data over encoding.
V*	Stand-by	Acquisition System	In case of equipment in stand by.
G*	Out of range	Acquisition System	Data out of analyzer range.
H*	Out of field	Acquisition System	Data out of QAL2 validity field.

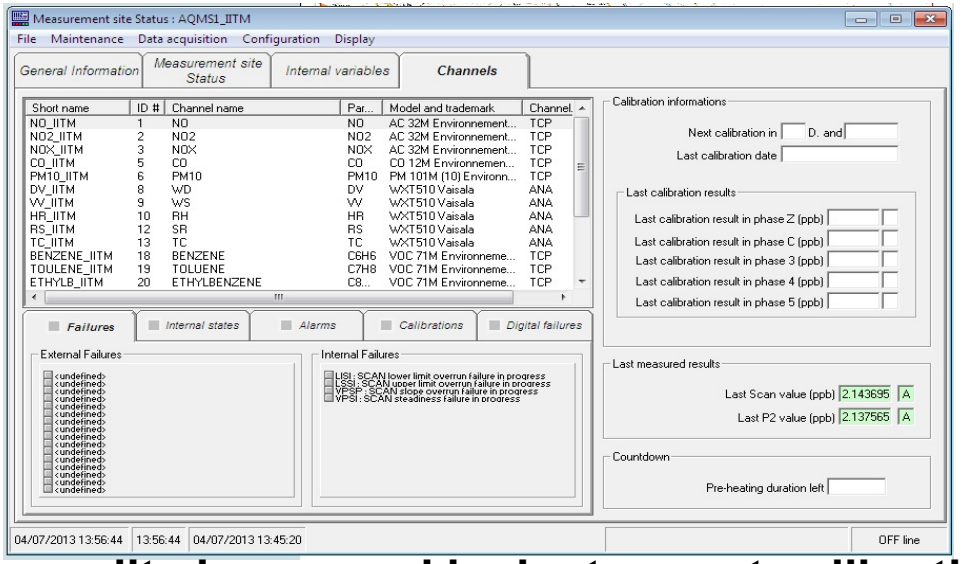
*Available for system SAM 6.0 and more
Data coded A, O, R, P, W or B are considered as **valid** and thus usable for calculations, diffusion, or utilisation by alert engines.
All other data is not used.

Quality Assurance & Quality Check Continued……

Identification of Problem on time : Assure data quality







Data loss is prevented and data quality is assured by instrument calibration , Review and Audit, Online monitoring and Data validation

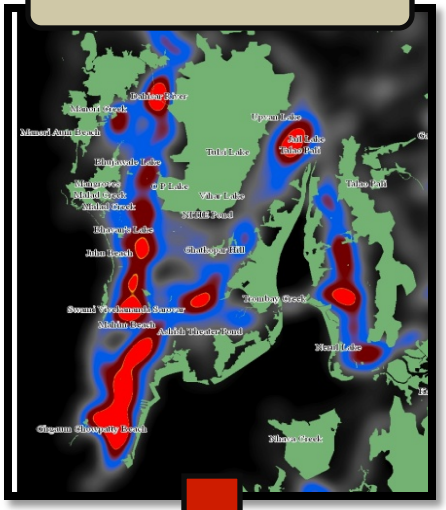
EMISSION INVENTORY DEVELOPMENT

Identification of sources, generating unavailable data involves extensive field survey

EMISSION INVENTORY Mega Campaign

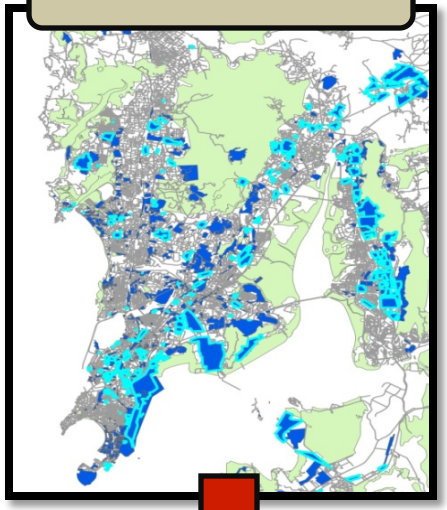
Efforts of more than 200 students – to collect unique region specific dataset

TRANSPORT SECTOR



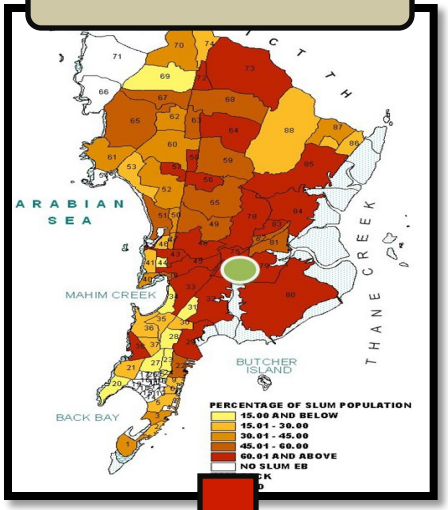
- Vehicle Density count on roads
- Fuel type used, VKT
- Road length
- % of paved and unpaved roads

INDUSTRIAL SECTOR



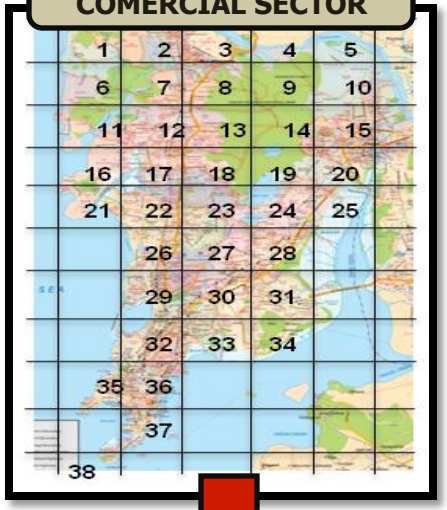
- Type of industries
- Fuel type used
- Fuel consumption
- NO. of industries

SLUM SECTOR



- Fuel consumption pattern
- Total consumption of fuel
- Hour of cooking
- No. of slum pockets

RESIDENCIAL & COMERCIAL SECTOR



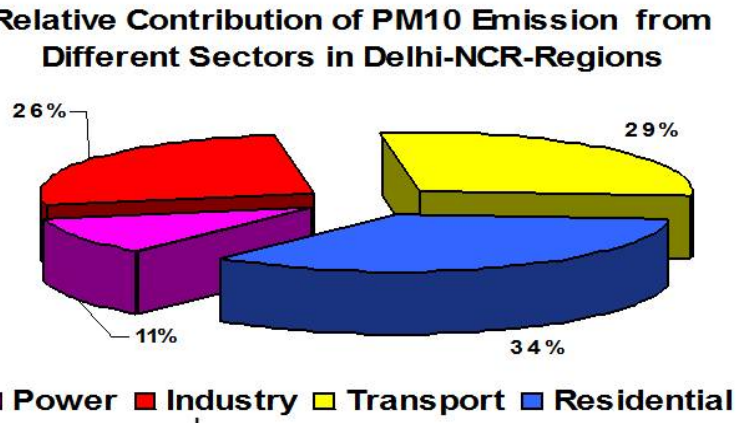
- Fuel consumption pattern
- Total consumption of fuel
- Hour of cooking
- No. of Hotels & Restaurants

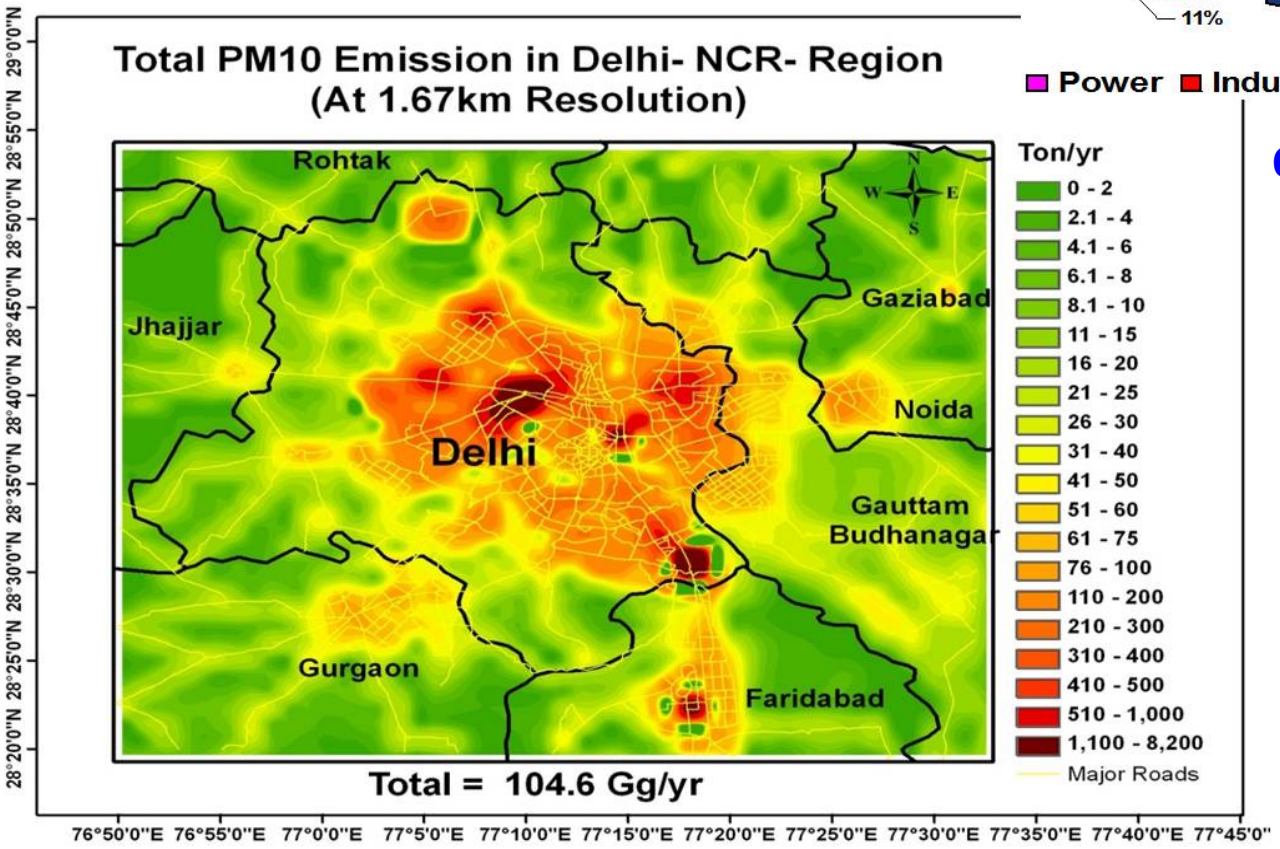
Real data : Need has been fulfilled

Real data : Need has been fulfilled

AIR POLLUTION HOT SPOTS

NCR-Delhi: PM10 INVENTORY for 2010

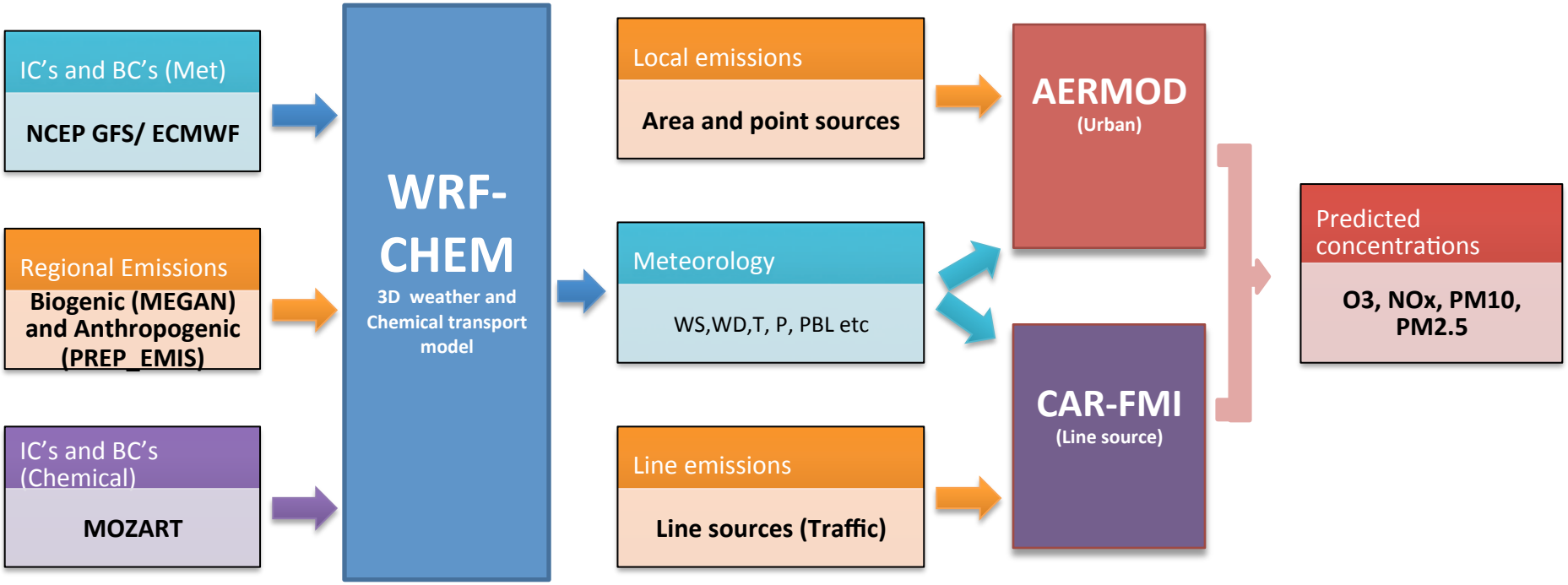




Quantify the contribution of various

Emission sources
(transport, industries, energy and bio-fuel)
in deteriorating air quality and climate.
Work towards unified country specific chemical-climate prediction system through observations
and modeling capabilities.

Coupled Regional-Urban-line source modelling system



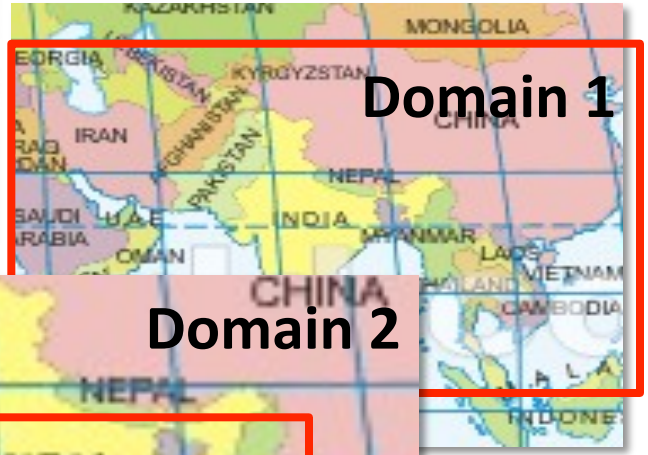
$$C_{Total} = C_{Regional} + C_{Urban} + C_{Road}$$

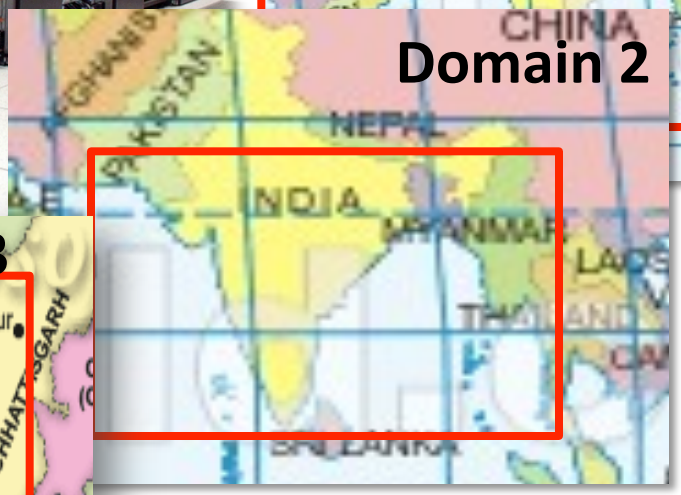
IMPROVE FORECASTING SKILLS

Fastest super computer in Pune

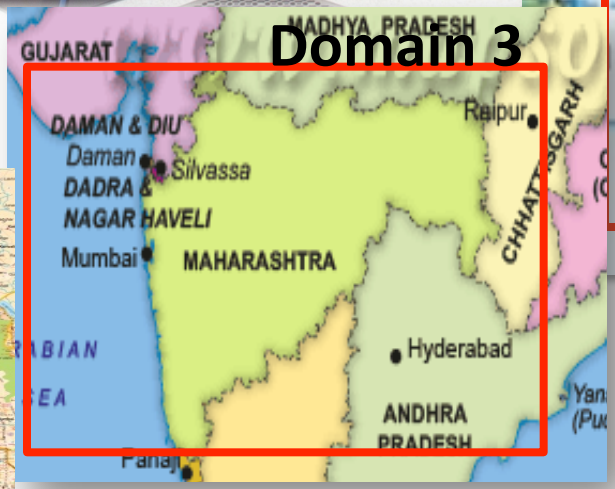
Coarse Domain

TWO WAY NESTING



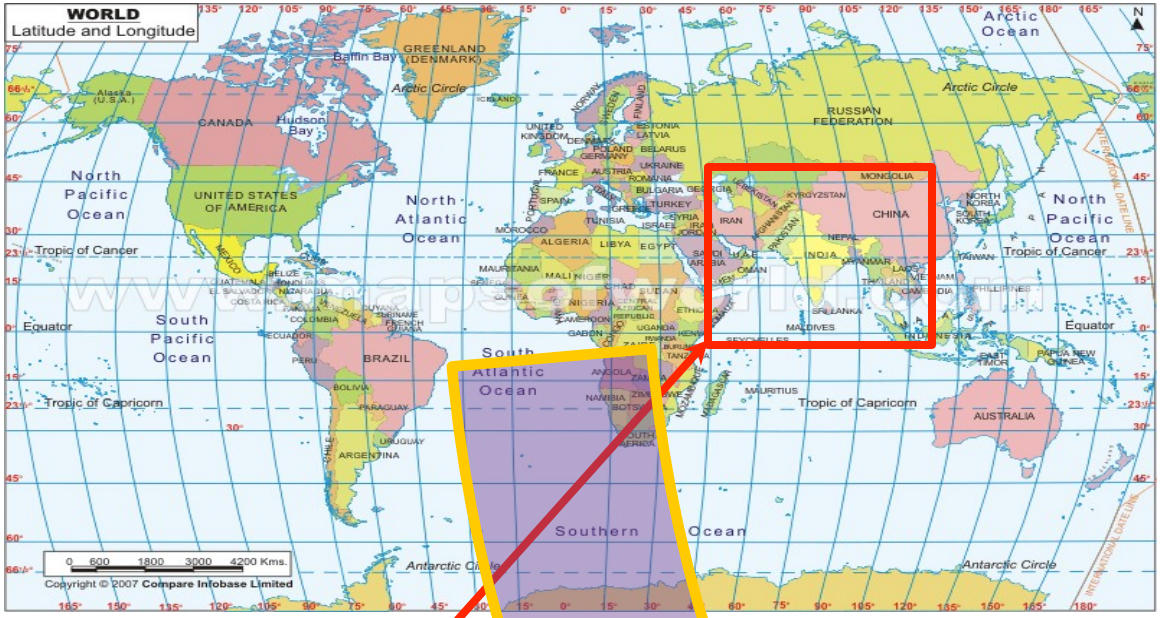


Fine Domain

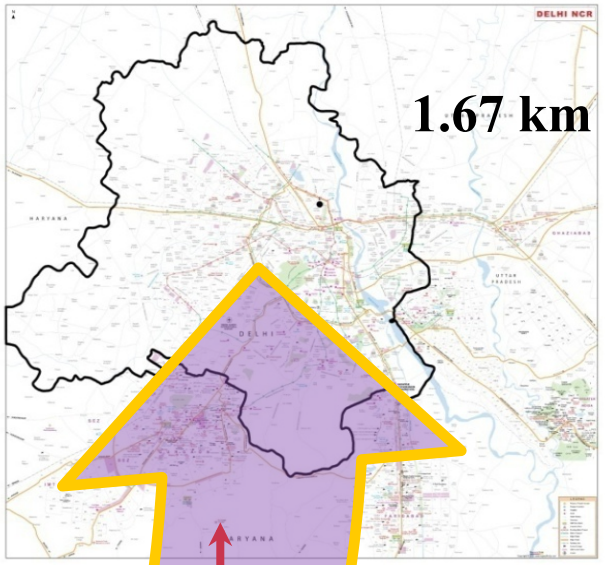


Meteorology → FEEDBACK → Aerosol

SAFAR- Delhi FORECAST Model:



Domain 4



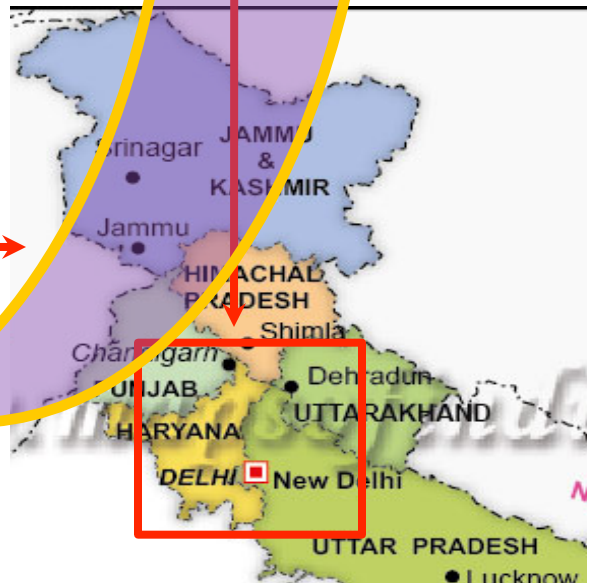
Domain 1

45 km

Domain 2

15 km

Domain 3



5 km

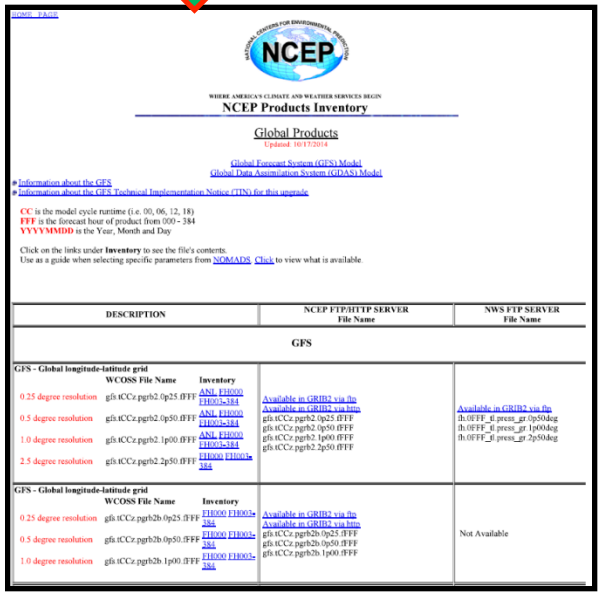
Boundary Conditions

CHEMISTRY & METEOROLOGY

```
#!/bin/bash
LINK=$(wget "http://ows-server.iek.fz-juelich.de/MACC_fnyp_fc-3hourly_ModelLevel?
service=WCS&Request=getcoverage&version=1.1.2&BoundingBox=40,-10,130,60,urn:ogc
:def:crs:OGC:2:84&format=application/x-netcdf&store=true&identifier=MACC_20130301" -
O - | grep "xlink:href="| cut -f 2 -d\")
wget ${LINK}
```

http://www.nco.ncep.noaa.gov/pmb/products/gfs

Run Stars at 12:12 PM, Runtime:21Hrs, Final Output: 10:00 AM



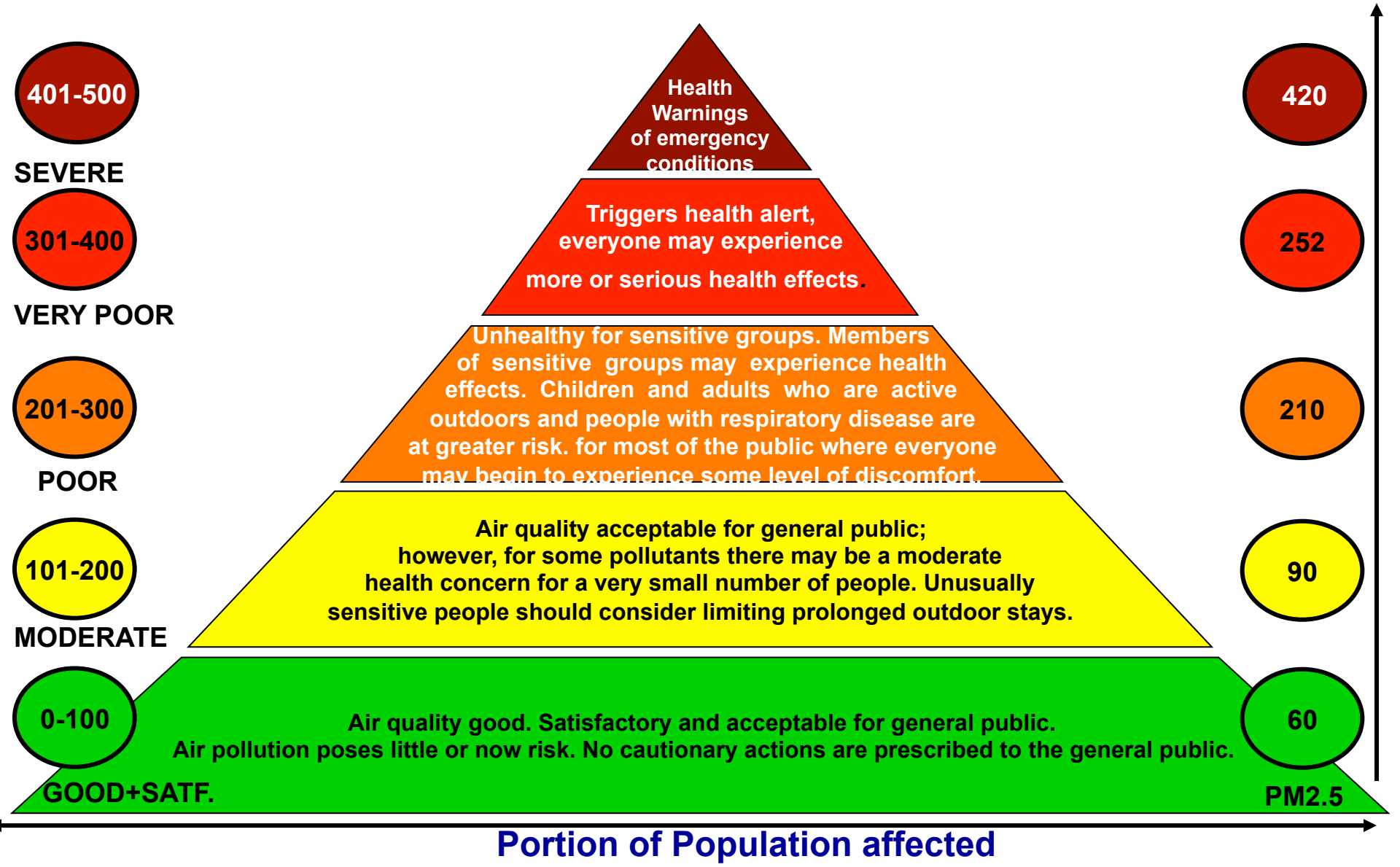
Awareness

Sharing Knowledge with Citizens /Students,….

AQI?

Air Quality Index (AQI) is a rating scale used for reporting the quality of air we breathe in and the associated health effects

AQI → Health Advisories



Communicate to Public :
Your MOOD ➡ Stress Level

Convert science in to common language – Numbers, Colours, Cartoons

Issue advisories based on data

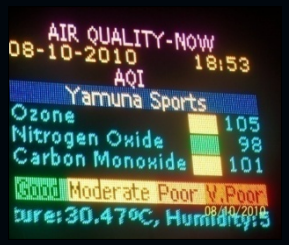
KNOW AIR QUALITY & WEATHER IN YOUR CITY

HOW?

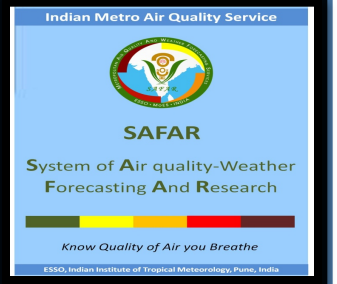
COMMUNICATION MEDIA

WEB-PORTAL
safar.tropmet.res.in

TOLL FREE NO.
1800 180 1717



LED SYSTEM
Digital Display Boards



MOBILE APP
SAFAR-AIR

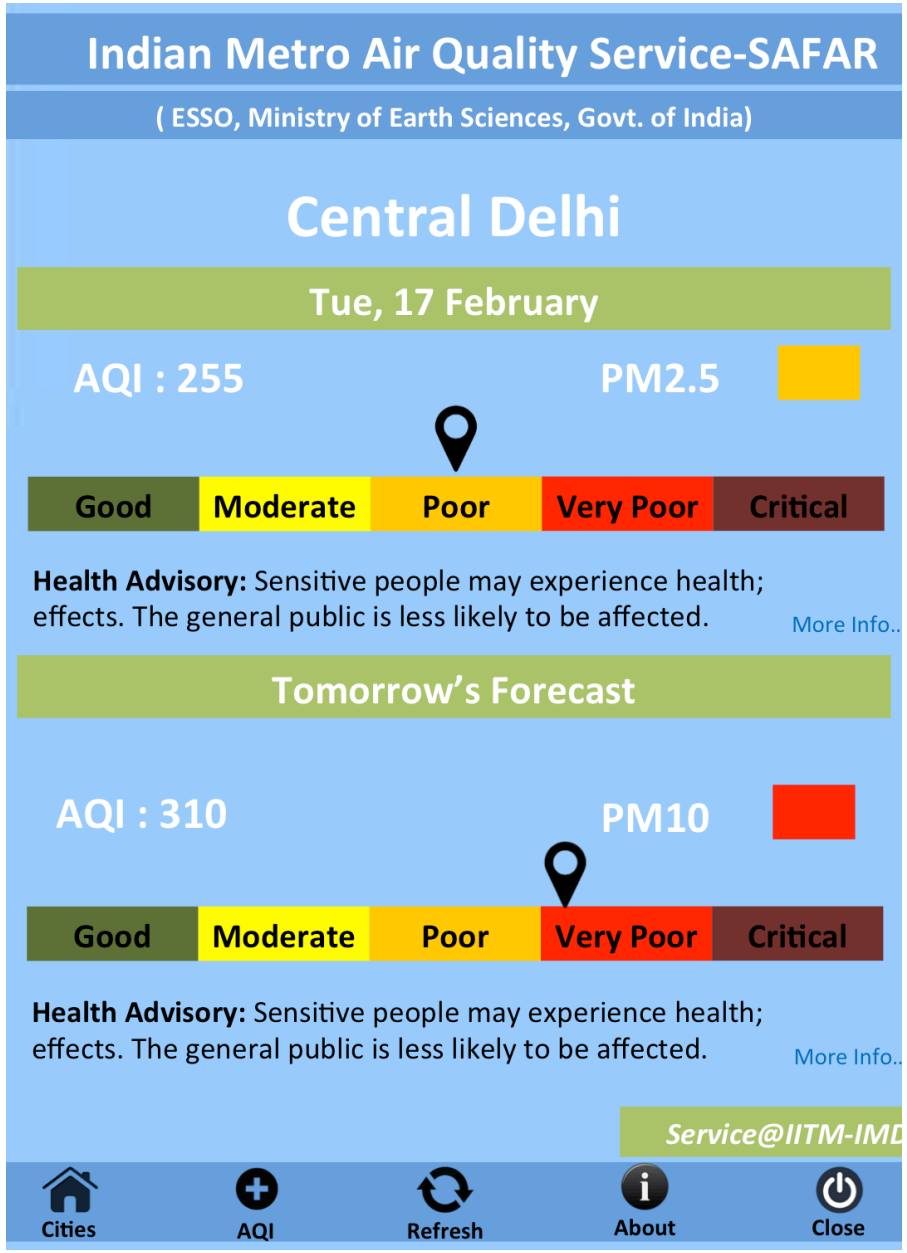
E-Mail: ALERT FOR EXTREME AIR POLLUTION AND WEATHER CONDITION

“Mobile App” Released on 17th Feb 2015 (14000 downloads so far)

SAFAR-Air

MOBILE APP

(Data on your tips)



POLLUTION TERROR

AIR QUALITY INDEX — PM2.5

Delhi	285	Poor
Tomorrow	299	Poor
Pune	136	Moderate
Tomorrow	141	Moderate

Source: **SAFAR@MoES-IITM-IMD** (10 stations)

Hyderabad	164	Unhealthy
Chennai	179	Unhealthy
Kolkata	219	Very Unhealthy
Mumbai	154	Unhealthy

Source: **US Embassy website**
Based on 1 Station Data Per City at 7pm
US Embassy uses a different AQI rating than India

28-Dec-2014

POLLUTION TERROR

AIR QUALITY INDEX — PM2.5

Delhi	344	Very Poor
Tomorrow	353	Very Poor
Pune	206	Poor
Tomorrow	213	Poor

Source: **SAFAR@MoES-IITM-IMD** (10 stations)

Hyderabad	160	Unhealthy
Chennai	159	Unhealthy
Kolkata	261	Very Unhealthy
Mumbai	164	Unhealthy

Source: **US Embassy website**
Based on 1 Station Data Per City at 7pm
US Embassy uses a different AQI rating than India

29-Dec-2014

POLLUTION TERROR

AIR QUALITY INDEX — PM2.5

Delhi	287	Poor
Tomorrow	309	Very Poor
Pune	208	Poor
Tomorrow	210	Poor

Source: **SAFAR@MoES-IITM-IMD** (10 stations)

Hyderabad	161	Unhealthy
Chennai	170	Unhealthy
Kolkata	238	V Unhealthy
Mumbai	174	Unhealthy

Source: **US Embassy website**
Based on 1 Station Data Per City at 7pm
US Embassy uses a different AQI rating than India

30-Dec-2014

POLLUTION BITES

AIR QUALITY INDEX — PM2.5

Delhi	332	Very Poor
Tomorrow	342	Very Poor
Pune	228	Poor
Tomorrow	230	Poor

Source: **SAFAR@MoES-IITM-IMD** (10 stations)

Chennai	157	Unhealthy
Kolkata	290	V Unhealthy
Mumbai	189	Unhealthy

Source: **US Embassy website**
Based on 1 Station Data Per City at 7pm
US Embassy uses a different AQI rating than India

31-Dec-2014

GAW Report No. 217

System of Air Quality Forecasting and Research

(SAFAR - India)

World Meteorological Organization
Weather · Climate · Water

GLOBAL ATMOSPHERE WATCH

GURME

WORLD METEOROLOGICAL ORGANIZATION
GLOBAL ATMOSPHERE WATCH

GAW Report No. 217

SYSTEM OF AIR QUALITY FORECASTING AND RESEARCH (SAFAR-INDIA)

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Indian Institute of Tropical Meteorology, Pune, India

June 2015

Metropolitan Air Quality and Weather Forecasting Service
SAFAR-Master Control Center, IITM, Pune

DIGITAL DATA WAREHOUSE

Atmospheric Pollution & Climate Change

SAFAR-Pune Implemented on 1st May 2013

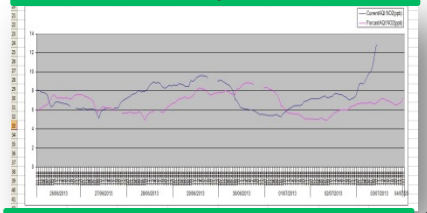
http://safar.tropmet.res.in/cityname
http://envis.tropmet.res.in

ONE SHOP

- Numerical Data Base
- Non- numerical Data Base
- Descriptive information

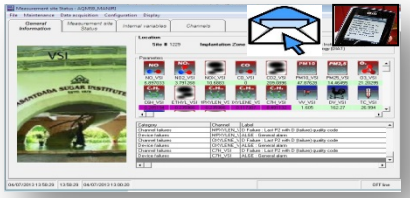
- *Air Quality Online*
- *GIS-Based visualization*
- *AQ Extreme Events*
- *Bibliography*

Forecast- Real Data Compare



Current status of AQMS & AWS

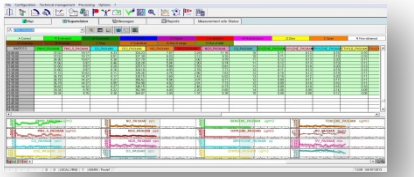
Alerts



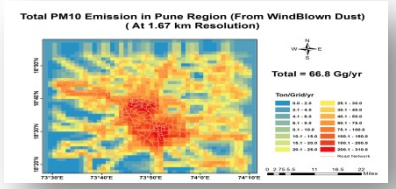
Current status of DDS

AQMS and AWS Network

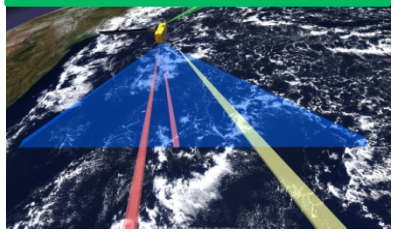
Historical Data



Emission Scenario

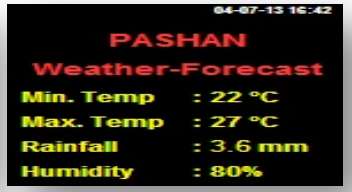


Satellite Data

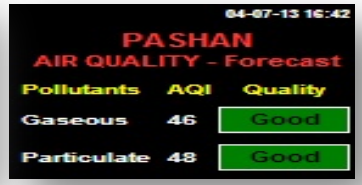


AQI & UVI

Weather Tomorrow



Air Quality Tomorrow



Dynamic Web portal